Bird-Window Collision Risks and Mitigation Strategies at Buchanan:

The University of British Columbia

Prepared by: Natalia Ważny

APBI 490

The University of British Columbia

April 12th, 2024

Executive Summary

With an expanding urban environment in most countries, cities like Vancouver are at a great risk of rising human-wildlife conflict due to the proximity of very productive ecosystems. In Canada alone, buildings with highly reflective glass contribute to the mortality of an estimated 25 million birds annually. Understanding the factors that lead to bird-window collisions in buildings is crucial, especially since collisions with man-made structures are the greatest human inflicted cause of avian mortality. Globally Birds often fail to recognize glass as a physical barrier and instead mistake it for open air, sky, or reflected vegetation, which resembles their natural habitat. Collisions are exacerbated by the increasing surface area of glass, as well as attractants such as dense vegetation near the windows, bodies of water, or bird feeders.This research project specifically focused on bird collisions at the Buchanan building located at the University of British Columbia. The aims of this study were to determine specifically how many bird collisions occurred at the Buchanan Building and whether the 2 Feather Friendly® retrofitted facades implemented in 2022 and 2023, effectively reduced the frequency of bird-window collisions on those facades. We also aimed to identify which facades at Buchanan were in urgent need of being retrofitted, since this might be the last year of data collection at this building. We hypothesized that the two facades retrofitted at Buchanan would see a reduction of collision frequency by about 95% since their installation. After our 8 weeks of data collection, we compiled and analyzed the bird collision from the past 4 years (2021-2024) and found that facades retrofitted with Feather Friendly markers were indeed 99%-100% effective at preventing bird collisions. Overall, there has been a noticeable 41% average decline in collisions at Buchanan each year. Vegetation, water and window reflectivity are the two main attractants still driving bird window collisions at many of the facades . Expanding projects across seasons at UBC could offer insights into seasonality effects on bird species and species-specific vulnerability. Investigating bird density and distribution beforehand could optimize mitigation strategy implementation. A practical suggestion could be to retrofit the three most problematic facades; 21, 26, and 31, which continue to contribute to collisions annually. Retrofitting these facades will further reduce collision rates. Alternatively, a cost-effective solution for Buchanan could involve installing hanging cords in front of office windows or enlisting volunteers to apply art designs on windows using oil-based markers or tempera paint, all of which have been proven effective as window deterrents. Sustained collaboration with the building management in this project is essential for raising awareness about bird-window collisions, potentially leading to increased awareness of the issue and the implementation of home-based solutions.The continued implementation of Feather Friendly® is a necessity at Buchanan and campus wide to reduce the severity of this human wildlife conflict UBC.

Table of Contents

Introduction

Bird-window collisions pose a significant threat to avian populations worldwide, with an estimated 10,000 incidents occurring annually on the University of British Columbia (UBC) campus alone (De Groot et al., 2021). This research project delves into the specific context of bird collisions at the Buchanan Building, situated within the UBC campus. The significance of this study lies in its exploration of the effectiveness of Feather Friendly® retrofitted facades, installed in 2022 and 2023, in mitigating bird-window collisions. The relevance of this research extends beyond the immediate campus environment to broader conservation efforts. By assessing the impact of these retrofitting measures, we aim to contribute valuable insights into strategies for reducing bird-window collisions not only at UBC but also in similar urban settings globally.

The Buchanan Building, as a focal point of this study, offers a unique opportunity to investigate the efficacy of Feather Friendly® markers in preventing bird collisions. With approximately 10,000 bird-window collisions recorded annually at UBC, understanding the effectiveness of retrofitting interventions becomes imperative in mitigating this threat to avian biodiversity (De Groot et al., 2021).The primary purpose of this research is to assess the impact of Feather Friendly® retrofitted facades on reducing bird-window collisions at the Buchanan Building. Specifically, we seek to quantify the frequency of bird collisions at this site. Furthermore, this study aims to identify facades within the Buchanan Building that are most urgently in need of retrofitting. Given that this research may represent the final year of data collection at this location, identifying priority areas for intervention becomes crucial for future conservation efforts. In line with these objectives, we hypothesize that the facades retrofitted with Feather Friendly® markers will experience a substantial reduction in collision frequency, potentially up to 95%, compared to pre-retrofitting levels (De Groot et al., 2021). Additionally, we anticipate that the density of vegetation surrounding windows may correlate with collision rates, providing further insights into factors influencing bird-window collisions.

This research project not only addresses a pressing conservation issue within the UBC campus but also contributes valuable knowledge to the broader field of urban wildlife management and conservation. Through rigorous data collection and analysis, we aim to inform evidence-based strategies for mitigating bird-window collisions.

Background

Human Wildlife Conflicts are a rising topic of discussion globally due to a concern for both the welfare of humans and the species involved (König et al. 2020). With an expanding urban environment in most countries, cities like Vancouver are at a great risk of rising human-wildlife conflict due to the proximity of very productive ecosystems. The lower mainland of British Columbia (BC) is on the Fraser River estuary and surrounded by temperate forests, both of which are home to a myriad of species (Langer et al., 2020). Human-wildlife conflicts are classified as interactions that occur between humans and wildlife, with a negative outcome for both, or one of these groups (Madden 2004). The unprecedented growth of the human population will only continue to exacerbate the severity of HWC, making these complex interactions an urgent issue for conservation and wildlife management (König et al. 2020). Within the scope of this paper, human-wildlife conflict refers to the frequency and occurrence of bird collisions with building windows and the resulting fatalities.

Many avian species are threatened by urban expansion, yet insufficient attention is given to this issue due to its invisibility. This conflict involves subtle dynamics not easily observed by humans; for example, birds colliding with windows often succumb to their injuries unnoticed (Gomez et al., 2022). In Canada alone, buildings with highly reflective glass contribute to the mortality of an estimated 25 million birds annually (Machtans et al. 2013; Loss et al., 2014). All buildings pose a significant threat to birds but residential and low rise buildings, such as those present on campuses are responsible for roughly 90% of bird-window collisions in urban environments (Hiemstra et al. 2020, Loss et al. 2014). Coastal BC stands out as a distinct habitat for bird species because it is situated along the Pacific Migratory flyway; a traveling route used by breeding and non-breeding birds (Ethier et al., 2020). In Vancouver, the presence of evergreen trees and milder temperatures, coupled with abundant vegetation coverage, creates a seasonal haven for many birds migrating from the North. This habitat supports species unique to the West Coast during these months (Butler et al. 2021). Nonetheless, the area witnesses a tragic toll on avian numbers, with hundreds of birds fatally colliding with windows each year (De Groot et al., 2021).

Understanding the factors that lead to bird-window collisions in buildings is crucial, especially since collisions with man made structures are the greatest human inflicted cause of avian mortality globally (Klem et al., 2004). Birds collide with windows because their sensory perception differs from that of humans. They often fail to recognize glass as a physical barrier and instead mistake it for open air, sky, or reflected vegetation, which resembles their natural habitat (Klem et al.,2009; Martin, 2011). Their lateral field vision is exceptional, but their frontal vision is frequently obstructed as they scour their surroundings for food or potential threats, heightening the risk of colliding with windows that blend into the environment. Their visual acuity and sensitivity to the ultraviolet spectrum make reflective structures such as windows challenging to discern during flight (Martin, 2011).Therefore, collisions are exacerbated by the increasing surface area of glass, as well as attractants such as dense vegetation near the windows, bodies of water, or bird feeders, further hindering the already limited field of view (Hager et al., 2017; Zulian et al. 2023). In numerous studies, it has been consistently demonstrated that window width, rather than height, significantly influences the frequency of collisions, making it one of the primary contributors of collisions (Himestra et al, 2020 & Nichols et al. 2018).

Specific-specific factors including bird physiology and behavior are also key determinants in the frequency of bird-window collisions (Hager & Craig. 2014). Habitat preferences, migratory patterns, and visual acuity all greatly affect collision likelihood and necessitate assessment in each region (Hager & Craig. 2014). Bird-Window Collisions occur all year round and at any time of day at UBC, however during the fall and spring migratory season there are notable increases in collision rates (De Groot, 2021). During the winter, species such as hummingbirds (*Trochilidae*), sparrows (*Passeridae*), and thrushes (*Turdidae*), are extremely susceptible to window collisions. Their agile flying behaviors add to the difficulty of promptly responding to obstacles in their flight path, frequently leading to fatal consequences (De Groot et al. 2021, Hiemstra et al. 2020). Night time collisions usually affect nocturnal birds such as Nightjars (*Caprimulgidae*) because they become disoriented with the presence of light in windows making them susceptible to collisions (Zulian et al. 2023). Interestingly, synanthropic species have been able to adapt to cohesively coexist in urban environments, so they are less likely to be involved in window-collisions due to the familiarity of their surroundings (Cusa et al. 2015).

Not all bird window collisions result in instant mortality, in fact most birds only succumb to their injuries hours or even days after the collision (Klem, 2009). Collisions result in subdural intracranial hemorrhaging and are present in 99% of collisions. More severe injuries are visible in larger birds where 30-60% of victims have visible blood or fluid present in their nose or mouth after the collision (Veltri & Klem, 2005).To mitigate the effects of this human-wildlife conflict, strategies like the installation of Feather Friendly® have shown remarkable effectiveness in reducing window collisions when properly implemented (De Groot et al., 2022). Other approaches adopted in North America include adding art to windows or installing homemade ropes outside windows to minimize reflectivity and provide visual cues for birds (Gomez-Martinez et al., 2019; De Groot et al., 2022).

Research Methodology and Methods

The methodology used in this project aligns with the data collection followed over the past three years at Buchanan. Initially devised by Hager & Cosentino (2014), it has since been modified by Krista De Groot. Our group consisted of three members that collected data over an 8 week period with a one week break halfway through due to reading week. The data collection commenced on January 28th, 2024 and ended April 29th 2024. Before commencing data collection, we cleaned the site of any signs of bird collisions the day prior. This process was then repeated one more time after our one week break. Evidence that was too high to clean was noted on a shared note on the phone, so that we could keep track of what evidence was already accounted for. As a team, we monitored the Buchanan buildings three times a week, in pairs, from Monday to Friday, for one hour between 8:00 am and 12:00 pm. Each surveyor was provided with a high-visibility vest, which was worn throughout the entire monitoring process. Additionally, each pair carried a plastic bag containing the necessary supplies and equipment. Inside each bag, there were ziploc bags for collecting evidence, a sharpie marker for labeling the evidence bags, gloves, a sanitary spray, and paper towels.

Prior to commencing research we all downloaded an app called Epicollect5 where we recorded all of our findings (Institute, 2017). When we cleaned for the first time, we practiced recording evidence into epicollect5 to ensure we knew how to work the app. This was different to previous years that had to manually input any evidence of collisions into a shared google drive.Whenever evidence was found, a comprehensive questionnaire was recorded in EpiCollect5. This included specific details such as the exact location, facade number, a photograph of the evidence, initials of the surveyor who discovered it, a clear description of its position on the facade, and the size of the evidence.

We began each monitoring session at facade 31, the entrance to Buchanan Block A on Main Mall. There were a total of 31 facades arranged into 5 building blocks (A,B,C,D,E). Surveyors assessed each of the 31 facades in opposite directions without communication, ensuring unbiased views and different angles to increase collision detection chances. Monitoring was done a meter away from the facade, with observers searching for evidence like feather smears, feather piles, or carcasses within a 2-meter radius. Binoculars were unavailable, so focus was on lower window panels, but any findings above were still noted. Feather smears with only one feather or those on spider webs were excluded. Start and end times were recorded on Epicollect5. If evidence was found, both surveyors walked around the building to document it. Unclear evidence was sent to our community partner, Simon Valdez, for clarification. If a feather smear was found, it was recorded and cleaned using gloves, paper towels, and sanitizing spray to prevent double counting. If it was a feather pile, it was collected in a ziplock bag, with the date, time, species (if identified), and the facade was recorded on the bag with a marker. One surveyor then took the evidence to the freezer in Macmillan building room 208 for further identification by our community partner. The same process applied to carcasses, with specific pictures taken of the dorsal, ventral, and lateral sides, noting whether it was partially scavenged or complete.

To study carcass disappearance rates after collisions, we carried out a carcass persistence trial from March 12th to March 14th, 2024. Simone Valdez placed two thawed carcasses randomly within the Buchanan complex: one hummingbird on Facade

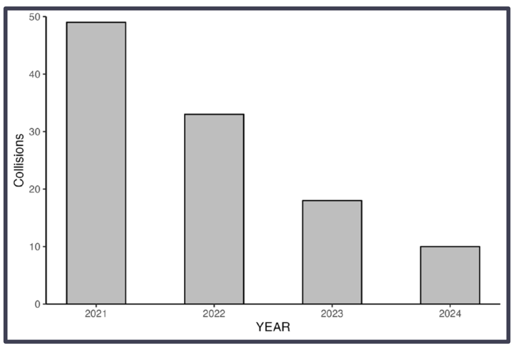
1 and one Varied Thrush on Facade 10. We documented their locations, took pictures, and noted placement details. Checking their status at 8:00 am, 12:00 pm, and 5:00 pm for two days, we recorded their presence or absence in a shared notes app. Once a carcass disappeared, we noted the last sighting time. On March 28th, 2024, a surveyor efficiency trial was conducted to assess the ability to locate a randomly assigned carcass at a Buchanan facade. The bird's back hallux was clipped for identification purposes, and it was randomly placed in a bush at Facade 17. Once found, the trial was completed, and the carcass was cleaned up and placed in the Macmillan freezer per standard procedure.

After our 8 weeks of data collection, Simon provided us with an Excel sheet containing data from the past 3 years of monitoring at Buchanan buildings (2021-2023). Using this information, we employed R software to analyze both our current and previous year's data, generating 5 graphs: (1) collision trends from 2021-2024, (2) total number of observations (3) collisions by block, (4) facades with the most consistent collisions, and (5) collisions at Retrofitted Facades. The retrofitted facades were marked with Feather Friendly® white dotted markers, with Facade A27 retrofitted in 2022 and Facade A25 in 2023. As Facade B29 was retrofitted midway through our 8-week trial period, its findings were not included in the analysis.

Results

During the 8-week data collection period, we documented 10 collisions at Buchanan. Graphs generated by the R software illustrate a steady decrease, marking a significant 79.6% reduction in collisions at this building complex since 2021. Since 2021, there has been a consistent yearly decline, averaging -41%. Figure 1 and Table 1, clearly depicts this decline, with 49 collisions recorded in 2021, 33 in 2022, 18 in 2023, and 10 in 2024.

Number of Collision Recorded at Buchanan (2021-2024)



Year	Number of Collisions
2021	49
2022	33
2023	18
2024	10

Table 1: The total number of collisions that occurred

Figure 1: A bar graph representing the number of bird-window collisions that occurred at the Buchanan building complex over a 4 year period (2021, 2022, 2023 and 2024).

Additionally, we examined the total number of observations recorded each year throughout the 8-week monitoring period. In 2022, the highest number of observations was recorded, totaling 995, while 2023 had the lowest overall observations, amounting to 619, indicating a 38% decrease. When combined, the total observations for 2021 and 2022 were 34% higher than those for 2023 and 2024.

Total Observation Count between 2021-2024 based on Evidence and No Evidence of Collisions Found

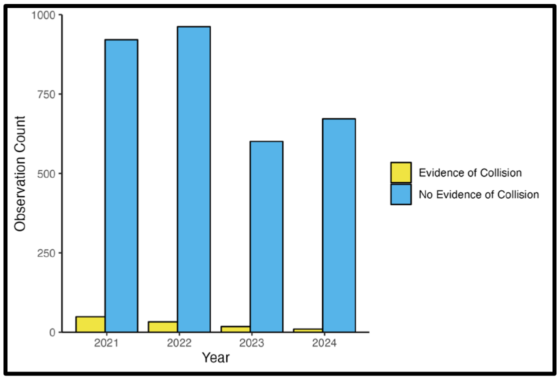


Figure 2: A bar graph representing the total number of observations carried out at Buchanan in 2021, 2022, 2023, and 2024. The yellow bars represent the number of observations with evidence of collisions and the blue bars represent observations with no evidence of collisions recorded.

To determine the block with the highest collision rate, we categorized the collisions into their respective groups as visible on figure 3. In 2024, every block experienced at least one collision. Block A had the highest number of collisions, totaling 4. Blocks B and D each had 2 collisions, while blocks C and E had one recorded collision each. block A accounted for 40% of bird window collisions at Buchanan in 2024.

Number of Collisions by Buchanan Blocks (A-E in 2024)

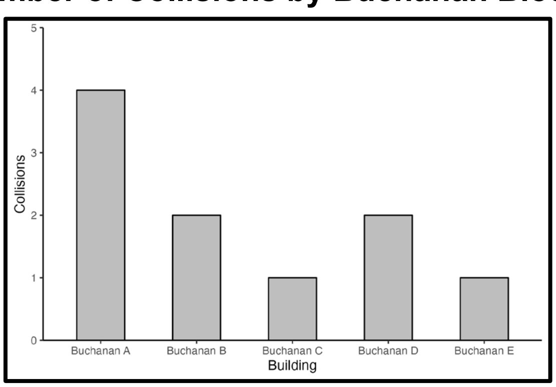


Figure 3: A bar graph representing the number of collisions that occurred by block at Buchanan ranging from block A-E in 2024.

Figure 4. clearly shows that facade A26, A31 and C21 have at least one recorded collision throughout all 4 years (2021-2024). 2021 shows the greatest number of collisions in A26 and C21 and an equal number of collisions to 2023 in facade A31. Although there has been a decline in the number of collisions recorded at these facades since 2021, bird window collisions are still a prominent issue.

Number of Collisions at Facades with Consistent Collisions at Buchanan (2021,2024)

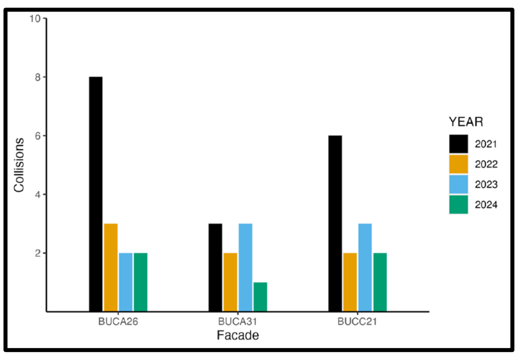


Figure 4: A bar graph representing collisions at the 3 facades; BUCA26, BUCA31, BUCC21 that have consistently shown collisions over the last 4 years (2021-2024). The black bar represents 2021, the orange bar represents 2022, the blue bar represents 2023 and the green bar represents 2024.

Finally, a key finding of this study examined the impact of retrofitted facades equipped with Friendly Markers®. Figure 5. illustrates a consistent downward trend in window collisions following facade retrofits. Before retrofitting, BUCA27 recorded 11 collisions in 2021. After the retrofit in 2022, only one collision was recorded, and there were none in 2023 and 2024. Similarly, BUCA25 had 5 collisions in 2021 and 6 in 2022 prior to retrofitting. Following the 2023 retrofit, collisions decreased to zero in 2023 and one in 2024, marking an approximate 99% decline post-retrofit.

Collision Frequency at Retrofitted Facades at Buchanan (2021-2024)

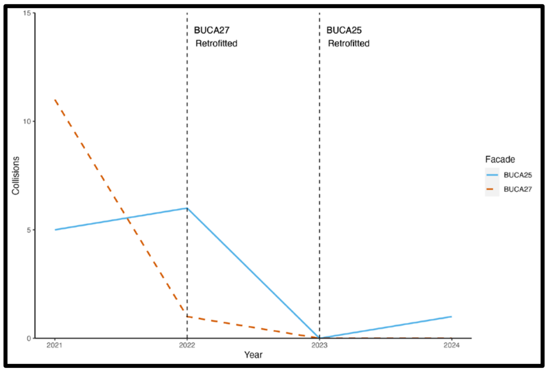


Figure 5: A line graph representing the collisions frequency at retrofitted facades buchanan for facade BUCA27 (blue line) and BUCA25 (orange broken line)

Regarding the surveyor efficiency trial, one out of two surveyors managed to locate the carcass during the monitoring period. For the carcass persistence trial, the Varied Thrush was actually moved within one hour of being placed into a bush nearby and then fully disappeared after 48 hours. Whereas the humming bird was still present two weeks after being placed.

Discussion

This year marks the final collection of bird-window collision data at Buchanan. Our primary objective was to assess the effectiveness of Feather Friendly® markers in reducing collision incidents. Our hypothesis suggested that buildings retrofitted with Feather Friendly® markers would experience a significant decline in collision rates. This hypothesis was validated, with observed reductions of 100% and 99% in collision rates in facades 27 and 27. These findings corroborate De Groot's (2022) estimation of a 95% reduction rate attributed to Feather Friendly® markers. The efficacy of these markers stems from their placement on the exterior of glass surfaces, minimizing reflectivity (Sheppard, 2019). Moreover, through tunnel vision testing, it has been noted that a close proximity (within 5 cm) between the markers and comprehensive coverage effectively deter birds by creating a dense visual barrier. This density prompts birds to alter their flight path, perceiving the decals as obstacles and allowing them adequate time to maneuver and avoid collisions (Sheppard, 2019). Overall, there has been a noticeable 41% average decline in collisions at Buchanan each year. This reduction is largely attributed to the installation of feather-friendly markers on two facades. However, the total observations in 2023 and 2024 also saw a 34% decrease, likely due to a reduction in monitoring personnel. With fewer monitors, the frequency of monitoring decreased, potentially contributing to the observed reduction in window collisions.

We hypothesized that facades with the highest density of nearby vegetation would show the most collisions. Our results partially support this hypothesis. In 2024, Buchanan block C had the lowest recorded collision frequency despite being surrounded by the most vegetation. However, facade 21 within block C consistently contributed to at least 2 collisions per year. Not surprisingly, there's abundant vegetation right next to this facade; a mix of tall trees, shrubs, and bushes located just 1 meter away from the windows. The windows on this facade are highly reflective and south facing, making them highly reflective on sunny days. Thus, the consistent contribution of this facade to window collisions aligns with literature emphasizing the significant impact of nearby vertical vegetation on collision frequency (Zulian et al., 2023).On the other hand, the proximity of vegetation to the building alone doesn't affect collision frequency (Zulian et al., 2023; Hiemstra et al., 2020). Therefore, the mix of vegetation types and heights near this facade could explain its consistent contribution to collisions. Although our data analysis didn't focus on specific species, a study by De Groot (2021) found that Varied Thrushes are among the most vulnerable species on the UBC campus to collisions. Since thrushes are forest-dwelling birds, they're more likely to be attracted to reflections of vegetation in windows.

Our hypothesis about vegetation coverage is partly correct because even though facade 26 also consistently causes collisions, there is no vegetation directly next to it. The area surrounding the facade is mostly cement, with a water fountain right across from it. Therefore, this facade may experience consistent collisions due to the high reflectivity of the windows and the proximity of the water source. Hummingbirds, which overwinter in British Columbia, are often attracted to feeders and flowers near buildings and windows, increasing collision risks (Hiemstra et al., 2020; Wittig et al., 2017). Additionally, Klem et al. (2009) noted that the presence of attractants such as water increases bird mortality rates and density near buildings, consequently increasing collision risk. Hence, it can be inferred that facade 26 experiences a higher number of collisions because of these factors.

The results of the surveyor efficiency trial coincide with previous literature, suggesting that not all observers will reliably locate a carcass (Riding & Loss, 2018). The detection ability of observers is notably affected by the substrate they are placed on, with studies indicating that carcasses are more easily detected on artificial substrates (Riding & Loss, 2018). The overall bias in observer detection has been thoroughly evaluated in numerous wildlife studies, revealing that observer detection diminishes due to factors such as observer inattentiveness or fatigue, as well as environmental conditions like vegetation coverage, poor lighting, and adverse weather conditions (Riding & Loss, 2018). Our trial assessing surveyor efficiency suggests that collision observations may be approximately 50% effective, potentially resulting in the overlooking of half of actual collisions and carcasses. The absence of any carcass findings during our 8-week period may be indicative of this trial outcome.

In the carcass persistence trial, we suspect a passerby relocated the varied thrush to a nearby bush within the first hour, possibly to clear it from the area. Factors contributing to the thrush's disappearance after 48 hours include the presence of scavengers such as coyotes, crows, seagulls, and raccoons throughout the 8-week monitoring period. Scavengers often remove carcasses from window areas, becoming accustomed to this human-wildlife conflict (Klem et al., 2004). Alternatively, human intervention may have caused the disappearance, as the carcass was clearly visible. The hummingbird's placement on a grate with gaps may have aided its unnoticed status, challenging scavengers and humans to spot it, contrary to literature (Riding & Loss, 2018). Additionally, the grate type may have limited access to the bird, and its distance from footpaths decreased the chance of human removal. Since the collision was staged without sound, scavengers were not alerted, reducing the likelihood of discovery.

Limitations of Research

During the 8 weeks of data collection, several limitations arose that might have affected the results. The absence of binoculars likely led to missing evidence above the first panel of windows, especially in buildings of at least 3 stories high, where most feather smears were less than 0.5 cm wide, severely limiting visibility. Hence, our focus was solely on lower-level windows, potentially missing about ⅓ of collisions on 3-story buildings, indicating that collision events could be more frequent than our findings suggest. As a three-person team, we surveyed the building three times a week, compared to the three to four times per week in 2021 and 2022, likely resulting in fewer detected collisions. For instance, the removal of the varied thrush within 48 hours underscores how an additional monitoring session could have improved our chances of finding a carcass.

Weather conditions also played a pivotal role in our monitoring efforts. Days characterized by heavy rain or snow made it challenging to inspect the facades, with raindrops washing away potential feather smears. Therefore, monitoring during Vancouver's coldest and rainiest months likely contributed to fewer collision observations. Weather is a key determinant of surveyor efficiency, explaining the absence of evidence of collisions on days with particularly poor conditions (Riding & Loss, 2018). Additionally, a major constraint limiting our access to facade 6 was the presence of large tree branches that were cut down and were not removed for over four weeks. This hindered our ability to closely observe for feather smears or carcasses at this facade. Also, ongoing construction in the area near Buchanan block E, may have resulted in a reduction in the bird population in that vicinity, thereby decreasing the rate of window collisions at that particular facade.

Recommendations

Despite decades of study on bird-window collisions, there are still many niche areas requiring exploration to mitigate their impact on avian species (Klem, 1989). While our findings support the effectiveness of Feather Friendly® markers, studies with larger sample sizes are needed to improve precision (Brown et al., 2019). Expanding projects across seasons at UBC could offer insights into seasonality effects on bird species and species-specific vulnerability. Investigating bird density and distribution beforehand could optimize mitigation strategy implementation (Gomez-Martinez et al., 2019). In Latin America, scientists have started leveraging museum collections and field data from citizens to develop effective deterrents against bird-window collisions, yielding promising results (Gomez-Martinez et al., 2019). Thus, I propose collaborating with Indigenous communities in BC to tap into local knowledge and centuries of experience with avian species (Kadykalo et al., 2021). Finally, conducting a study at UBC in partnership with the Wildlife Rescue Association of BC, which receives numerous public calls regarding window collisions in the lower mainland, would be intriguing. Examining the outcomes of window collision injuries and the survival rates of birds involved could vividly illustrate the gravity of this conflict and raise awareness about the impact of bird-window collisions.

The management of the Buchanan building has made significant strides in retrofitting some of the most problematic facades since the inception of this project four years ago. Retrofitting these facades has had a profound impact on mitigating the occurrence of window collisions in the building. A practical suggestion would be to retrofit the three most problematic facades; 21, 26, and 31, which continue to contribute to collisions annually. Retrofitting these facades will further reduce collision rates. Alternatively, a cost-effective solution for Buchanan could involve installing hanging cords in front of office windows or enlisting volunteers to apply art designs on windows using oil-based markers or tempera paint, all of which have been proven effective as window deterrents (Gomez-Martinez et al., 2019; De Groot et al., 2022). Additionally, Buchanan is surrounded by abundant vegetation, so regular maintenance of the vegetation, particularly by removing large branches near windows that could attract birds, may help decrease collision frequency (Brown et al., 2019). Sustained collaboration with the building management in this project is essential for raising awareness about bird-window collisions, potentially leading to increased awareness of the issue and the implementation of home-based solutions (Brown et al., 2019).

Conclusion

Conservation and mitigation efforts, like our 8-week project at Buchanan, are crucial for reducing bird-window collisions on the UBC campus and preserving bird species in BC. Birds play a vital role in ecosystem health, including pollination and seed dispersal, particularly in productive areas like the Fraser River estuary (Butler et al. 2021). Factors contributing to collisions include vegetation height, window reflectivity, size, and water presence (Klem Jr et al.,2004;Klem et al.,2009;Martin, 2011). Understanding these factors informs effective mitigation strategies like Feather Friendly Markers. Species-specific physiology, migratory behavior, and spectral sensitivities compared to humans are essential considerations for conservation. The significant decline in collision frequencies at Buchanan, especially with Feather Friendly® markers, is promising for UBC's Campus Vision 2050, which prioritizes human-wildlife coexistence. Addressing urban bird mortality, a major concern, aligns with this vision. Buchanan can serve as a model for coexistence as more buildings adopt large glass facades around campus.

References

1. Brown, B. B., Kusakabe, E., Antonopoulos, A., Siddoway, S., & Thompson, L. (2019). Winter bird-window collisions: mitigation success, risk factors, and implementation challenges. *PeerJ*, *7*, e7620.
2. Butler, R. W., Bradley, D. W., & Casey, J. (2021). The status, ecology and conservation of internationally important bird populations on the Fraser River Delta, British Columbia, Canada. *British Columbia Birds*, *35*, 1-52.
3. Cusa, M., Jackson, D. A., & Mesure, M. (2015). Window collisions by migratory bird species: Urban geographical patterns and Habitat Associations. *Urban Ecosystems*, *18*(4), 1427–1446. https://doi.org/10.1007/s11252-015-0459-3
4. De Groot, K. L., Porter, A. N., Norris, A. R., Huang, A. C., & Joy, R. (2021). Year-round monitoring at a Pacific coastal campus reveals similar winter and spring collision mortality and high vulnerability of the Varied Thrush. *The Condor*, *123*(3), duab027
5. De Groot, K. L., Wilson, A. G., McKibbin, R., Hudson, S. A., Dohms, K. M., Norris, A. R., ... & Wilson, S. (2022). Bird protection treatments reduce bird-window collision risk at low-rise buildings within a Pacific coastal protected area. *PeerJ*, *10*, e13142.
6. Ethier, D., Davidson, P., Sorenson, G. H., Barry, K. L., Devitt, K., Jardine, C. B., ... & Bradley, D. W. (2020). Twenty years of coastal waterbird trends suggest regional patterns of environmental pressure in British Columbia, Canada. *Avian Conservation & Ecology*, *15*(2).
7. Gomez, J., van Vliet, N., & Canales, N. (2022). The values of wildlife revisited. *Ecology and Society*, *27*(4)
8. Gómez-Martínez, M. A., Klem, D., Rojas-Soto, O., González-García, F., & MacGregor-Fors, I. (2019). Window strikes: bird collisions in a Neotropical green city. *Urban Ecosystems*, *22*, 699-708
9. Hager, S., & Cosentino, B. (2014). Surveying for bird carcasses resulting from window collisions: a standardized protocol. doi: 10.7287/peerj.preprints.406v1
10. Hager, S. B., Cosentino, B. J., Aguilar-Gómez, M. A., Anderson, M. L., Bakermans, M., Boves, T. J., ... & Zuria, I. (2017). Continent-wide analysis of how urbanization affects bird-window collision mortality in North America. *Biological Conservation*, *212*, 209-215
11. Hiemstra, M. A., Dlabola, E. K., & O'Brien, E. L. (2020). Factors influencing bird-window collisions in Victoria, British Columbia. *Northwestern naturalist*, *101*(1), 27-33
12. Institute, O. U. B. D. (2017, January 1). *Free and easy-to-use mobile data-gathering platform.* Epicollect5: Mobile & Web Application for free and easy data collection. https://five.epicollect.net/

13. Kadykalo, A. N., Cooke, S. J., & Young, N. (2021). The role of western-based scientific, Indigenous and local knowledge in wildlife management and conservation. *People and Nature*, *3*(3), 610-626
14. Klem, D., Keck, D. C., Marty, K. L., Ball, A. J. M., Niciu, E. E., & Platt, C. T. (2004). Effects of window angling, feeder placement, and scavengers on avian mortality at plate glass. *The Wilson Bulletin*, *116*(1), 69-73
15. Klem, D., Farmer, C. J., Delacretaz, N., Gelb, Y., & Saenger, P. G. (2009). Architectural and landscape risk factors associated with bird–glass collisions in an urban environment. *The Wilson Journal of Ornithology*, *121*(1), 126-134
16. Klem Jr, D. (2009). Avian mortality at windows: the second largest human source of bird mortality on earth. In *Proceedings of the Fourth International Partners in Flight Conference: Tundra to Tropics* (Vol. 244251).
17. Klem Jr, Daniel. "Bird: window collisions." *The Wilson Bulletin* (1989): 606-620.
18. König, H. J., Kiffner, C., Kramer-Schadt, S., Fürst, C., Keuling, O., & Ford, A. T. (2020). Human–wildlife coexistence in a changing world. *Conservation Biology*, *34*(4), 786-794
19. Langer, O. E., Hietkamp, F., & Farrell, M. (2020). Human population growth and the sustainability of urban salmonid streams in the lower Fraser Valley. In *Sustainable Fisheries Management* (pp. 349-361). CRC Press.
20. Loss SR, WillT, Loss SS, Marra PP. 2014. Bird-building collisions in the United States: Estimates of annual mortality and species vulnerability. The Condor: Ornithological Applications 116:8-23.
21. Madden F. 2004. Creating coexistence between humans and wildlife: global perspectives on local efforts to address human–wildlife conflict. *Human Dimensions of Wildlife* 9: 247–257.
22. Machtans, C. S., Wedeles, C. H., & Bayne, E. M. (2013). A first estimate for Canada of the number of birds killed by colliding with building windows. *Avian Conservation & Ecology*, *8*(2)
23. Martin, G.R. 2011. Understanding bird collisions with man made objects: a sensory ecology approach. Ibis. 153, 239-254.
24. Nichols KS, Homayoun T, Eckles J, Blair RB. 2018. Bird-building collision risk: An assessment of the collision risk of birds with buildings by phylogeny and behavior using two citizen-science datasets. PLoS ONE 13:e0201558.th
25. Riding, C. S., & Loss, S. R. (2018). Factors influencing experimental estimation of scavenger removal and observer detection in bird–window collision surveys. *Ecological Applications*, *28*(8), 2119-2129.
26. Sheppard, C. D. (2019). Evaluating the relative effectiveness of patterns on glass as deterrents of bird collisions with glass. *Global Ecology and Conservation*, *20*, e00795

27. Veltri, C. J., & Klem, D. (2005). Comparison of fatal bird injuries from collisions with towers and windows. *Journal of Field Ornithology*, *76*(2), 127-133.
28. Zulian, V., Norris, A. R., Cockle, K. L., Porter, A. N., Do, L. G., & De Groot, K. L. (2023). Seasonal variation in drivers of bird-window collisions on the west coast of British Columbia, Canada. *Avian Conservation and Ecology*, *18*(2).